# Ultrafast dynamics of complex atoms induced by coherent laser

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With the development of highly bright coherent X-ray lasers and attosecond extreme-ultraviolet pulses, the strong field physics of light-matter interactions has expanded from the long-wavelength regime into the short-wavelength regime. Here, one experimentally provides the possibility for investigating the coherent dynamics of X-ray-matter systems (also attosecond extreme-ultraviolet pulse induced systems). In contrast to traditional studies, these non-equilibrium systems normally relax in a vast number of decay channels, and the corresponding dominant physical mechanism can be treated as the interplay between coherence and dissipation. Unfortunately, in spite of recent experimental progresses, simulations for these open systems are so far completely lacking, since a large-scale simulation is inevitable for the intense X-ray-matter systems.

Both coherent pumping and energy relaxation play important roles in understanding physical processes of ultra-intense coherent light-matter interactions. Here, using a large-scale quantum master equation approach [1], we describe dynamical processes of practical open quantum systems driven by both coherent and stochastic interactions. As examples, two typical cases of light-matter interactions are studied. First, we investigate coherent dynamics of inner-shell electrons of a neon gas irradiated by a high intensity X-ray laser along with vast number of decaying channels. In these single-photon dominated processes, we find that, due to coherence-induced Rabi oscillations and power broadening effects, the photon absorptions of a neon gas can be suppressed resulting in differences in ionization processes and final ion-stage distributions. Second, we take helium as an example of multiphoton and multichannel interference dominated electron dynamics, by investigating the transient absorption of an isolated attosecond pulse in the presence of a femtosecond infrared laser pulse. In the last part, we demonstrate a new scheme for the investigation of hole dynamics of complex atoms based on two-color ultrashort X-ray pulses.

## REFERENCES

[1] Yongqiang Li, Cheng Gao, Wenpu Dong, Jiaolong Zeng, Zengxiu Zhao and Jianmin Yuan, '*Coherence and resonance effects in the ultra-intense laser-induced ultrafast response of complex atoms*' Scientific Reports **5**,18529 (2016).